Ionic Monopropellant Product Characterization

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Ionic monopropellants are an emerging technology with the potential to replace hydrazine and nitrogen tetroxide for propulsion and power. Monopropellant alternatives to hydrazine have garnered increasing interest due to their relatively safe, nontoxic, and environmentally benign properties, potential attractive propellant performance characteristics, and lower cost in handling. The United States Air Force (USAF) and other Department of Defense agencies are actively pursuing investigations into these monopropellants, and NASA has supported limited testing for these agencies in addition to its own testing. It is likely that NASA will consider ionic monopropellants as potentially viable on future spacecraft. Testing requirements are more stringent for NASA than other agencies due to crewed spacecraft considerations; therefore, testing has been proposed in NASA Johnson Space Center's White Sands Test Facility (WSTF) laboratory, propulsion areas, and larger-scale testing in the WSTF hazardous fluids test area.

Characterization of the products of liquid ionic monopropellants for spacecraft propulsion is in accordance with green propellant initiatives, and the demand for high-performance propellants has already led to increased information into the formulation, testing, and characterization of ionic monopropellants developed by the USAF such as AF-M315E, and others developed by different agencies including the Swedish Defense Agency. Some of the benefits of AF-M315E are that, as a monopropellant, it offers bipropellant performance; the system footprint would be smaller, meaning fewer parts, a reduced system risk, and increased payload; and because it would be a hydrazine replacement, the monopropellant offers reduced toxicity/carcinogenicity. An off-gassed product evaluation of AF-M315E was conducted at WSTF, and the results were reported to the USAF for evaluation.

The performance of ionic monopropellants has been compared with hydrazine, but with greatly reduced vapor toxicity. However, one area that needs study is the identification of combustion and non-combustion by-products. Combustion and non-combustion products are a concern for a variety of reasons including plume impingement on sensitive surfaces, extravehicular activity operations where contamination could occur, and vehicle health—e.g., the formation of potentially explosive products such as Fuel/Oxidizer Reaction Products (as was learned from the Space Shuttle Program) and other compounds believed in part responsible for "hard starts" in other programs.

An innovative test program is under way at WSTF to determine combustion and non-combustion products of ionic monopropellants. A gas chromatograph with a mass spectrometer detector will be configured to pack the injector inlet with selected catalyst material. Ionic monopropellant (microliter quantities) will be injected onto the catalyst bed and products swept into the detector for identification. The temperature of the catalyst in the inlet will be varied and product distribution characterized as a function of temperature. The data will be used to assess environmental and safety hazards of the ionic monopropellant products. A literature survey of work reported to date will also be performed.